

Taxonomy and distribution of fossil *Archivesica* (Bivalvia: Vesicomysidae) in Japan

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ABSTRACT

Six species of vesicomysid bivalves of the genus *Archivesica* occur in the Neogene of Japan, one further species is assigned here to this genus, but with some hesitation. Among these six species, two are herein described as new: *A. shikamai* from the Pliocene Ikego Formation on the Pacific side of Honshu and *A. kannoi* from the lower Pliocene Kurokura Formation on the Japan Sea side of Honshu; one species, the late Miocene *A. shiretokensis*, has recently been described; two species, the late Miocene to early Pliocene *A. nipponica* and the Pliocene *Archivesica* sp. were previously regarded as belonging to *Calypptogena* but are herein transferred to *Archivesica*. The extremely large Pliocene "*Calypptogena*" *bosoensis* closely resembles modern species of *Archivesica* from the western Pacific rather than species of *Calypptogena* and is herein hesitantly assigned to *Archivesica*. Compared to Paleogene species of *Archivesica* from the northern and eastern side of the North Pacific, the Neogene Japanese species differ by being larger and by lacking a lunular incision. We suggest that this group of large *Archivesica* species originated in the western Pacific during the Miocene and spread to the coast of western North America by the Pliocene. The impressive diversification of these "large *Archivesica*" species since the late Miocene might be related to the coeval decline in diversity of the elongate vesicomysid genus *Adulomya* in Japan.

Additional keywords: Neogene, new species, bivalves, *Calypptogena*

INTRODUCTION

The Vesicomysidae is a species-rich deep-water bivalve family frequently found at hydrothermal vents, cold seeps, and decaying whale carcasses. Its fossil history can be traced back to the middle Eocene (Amano and Kiel, 2007). In Japan, which has a rich record of exposed Cenozoic deep-water sediments, fossil vesicomysids are known from cold-seeps, whale-falls, and organic-rich shales. In previous studies we treated members of the genera *Adulomya* Kuroda, 1931, *Calypptogena* Dall, 1891, and *Hubertschenckia* Takeda, 1953 (Kanno et al., 1989; Amano and Kiel, 2007; Amano and Kiel, in press).

Members of the genus *Archivesica* have the largest shells among all the vesicomysids, three radiating cardinal teeth, a subumbonal pit and a shallow pallial sinus. Shells with such characteristics have been reported mainly from the Pliocene deposits in the Japan Sea side of central Honshu and the Pacific side of southwestern Honshu, and include *Akebiconcha kawamurai* Kuroda, 1943 and *Calypptogena nipponica* Oinomikado and Kanehara, 1938 and various species in open nomenclature (Majima et al., 2005). These names, however, are often used in a confusing and inconsistent manner, partly because the type material of *Calypptogena nipponica* was poorly preserved and is now lost. The purpose of the present study is to summarize the taxonomy and the distribution of the fossil Japanese species of *Archivesica* Dall, 1908 and discuss the evolutionary history of this genus.

MATERIALS AND METHODS

The new species described herein are from two Pliocene formations in Honshu, Japan (Figure 1). The specimens were collected from turbidite deposits of the Pliocene Ikego Formation at Ikego, Zushi City in Kanagawa Prefecture (Figure 1, Loc. 1). Some of these specimens had previously been described as *Calypptogena* cf. *nipponica* or *Calypptogena* sp. 1, and C. sp. 2 (Kanno, 1991, 1993). Further specimens were extracted from large calcareous concretion in the Pliocene part of the Kurokura Formation at Matsudai, Tokamachi City in Niigata Prefecture (Figure 1, Loc. 3). Some of these specimens had previously been described as *Calypptogena* cf. *nipponica* by Amano and Kanno (2005). All new material is housed in the Joetsu University of Education. In addition, we examined specimens identified as *A. kawamurai clongata* Ozaki, 1958 from the Pliocene Na-arai Formation at Choshi (Figure 1, Loc. 2) in Chiba Prefecture, which are housed at National Science Museum (Ozaki, 1958).

Institutional Abbreviations: ESN: Furukawa Museum of Nagoya University; IGSU: Institute of Geoscience, Shizuoka University; JUE: Joetsu University of Education;

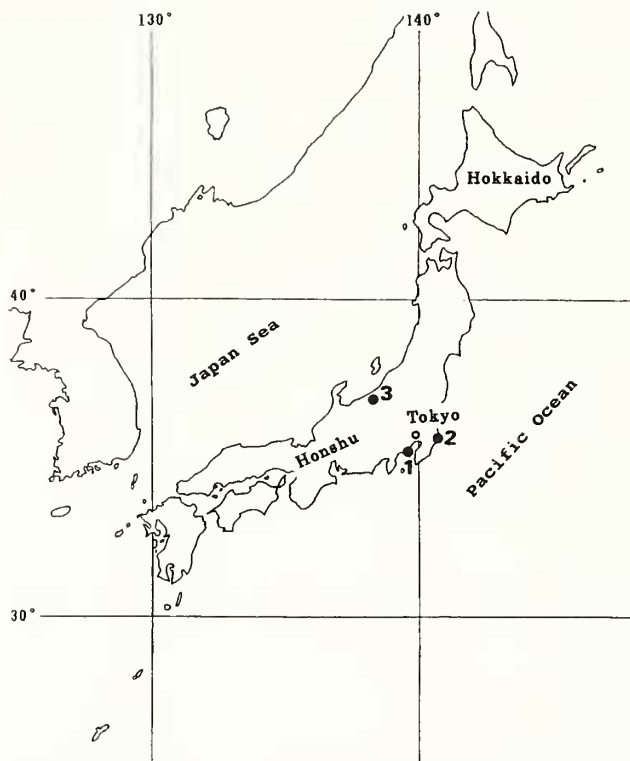


Figure 1. Locality map for fossil species of *Archivesica* in Japan.

NSMT-Mo: National Science Museum, Tokyo, Molluscan collection; NSM: National Science Museum (Paleontology); YCM-GP: Yokosuka City Museum, Yokosuka, Geology and Paleontology.

SYSTEMATICS

Family Vesicomidae Dall and Simpson, 1901

Genus *Archivesica* Dall, 1908

Type species: *Callocardia gigas* Dall, 1896 from the Gulf of California.

Archivesica kawamurai (Kuroda, 1943)
(Figures 2–13, 19, 23)

- Akebiconcha kawamurai* Kuroda, 1943: 14–18, pl. 13, text-figs. 1–3; Habe, 1951: 117–118, figs. 246, 249; Ozaki, 1958: 124, pl. 3, figs. 1–3, pl. 5, figs. 1, 2; Habe, 1961: pl. 55, fig. 16; Shikama, 1962: 53, pl. 3, figs. 6a–b, 7a–e; Okutani, 1966: 300, pl. 28, fig. 3; Habe, 1977: 237, pl. 50, figs. 3, 4; Noda, 1980: 89–90, pl. 1, fig. 21, pl. 4, fig. 21; Tsuchida, 1986: 29–30, fig. 2; Horikoshi, 1989: 64–66, figs. 4–6; Kanno, 1993: pl. 9, figs. 1–3; Nobuhara and Tanaka, 1993: 30, 32, pl. 1, figs. 8–12; Nobuhara and Takatori, 1999: pl. 1, fig. 11.
- Akebiconcha kawamurai elongata* Ozaki, 1958: 123, pl. 5, figs. 3, 4, pl. 6, figs. 3–5. (*non* pl. 6, figs. 1, 2).
- Akebiconcha nipponica* (Oinomikado and Kanehara).—Shikama and Masujima, 1969: pl. 7, figs. 16–19.
- Archivesica* (*Akebiconcha*) *kawamurai* (Kuroda).—Keen, 1969: N664, figs. E138–7a–c.
- Calyptogena* sp. Majima et al., 1990: figs. 3A–D. (*non* figs. 3Ea,b).

Calyptogena cf. *nipponica* Oinomikado and Kanehara. Kanno, 1990: 93–95, pl. 5, figs. 1–3. (*non* pl. 6, figs. 1, 2); Kanno, 1991: pl. 2, figs. 2a–c, pl. 3, figs. 1–4.

Calyptogena solidissima Okutani, Hashimoto and Fujikura, 1992: 226–230, fig. 2–8; Okutani, 2000: 999, pl. 497, fig. 15.

Calyptogena sp. 2. Kanno, 1993: 133–135, pl. 3, fig. 1–10.

Calyptogena (*Archivesica*) *kawamurai* (Kuroda). Sasaki et al., 2005: fig. 10; Okutani, 2000: 999, pl. 497, fig. 15; Okutani, 2008: fig. 8.90.

Vesicomya (*Calyptogena*) *kawamurai* (Kuroda).—Nobuhara, 2003: fig. 3–7–12.

Type Material: Holotype NSMT-Mo 60915, off Odawara City, Sagami Bay.

Material Examined: Thirteen specimens from Loc. 1 were examined.

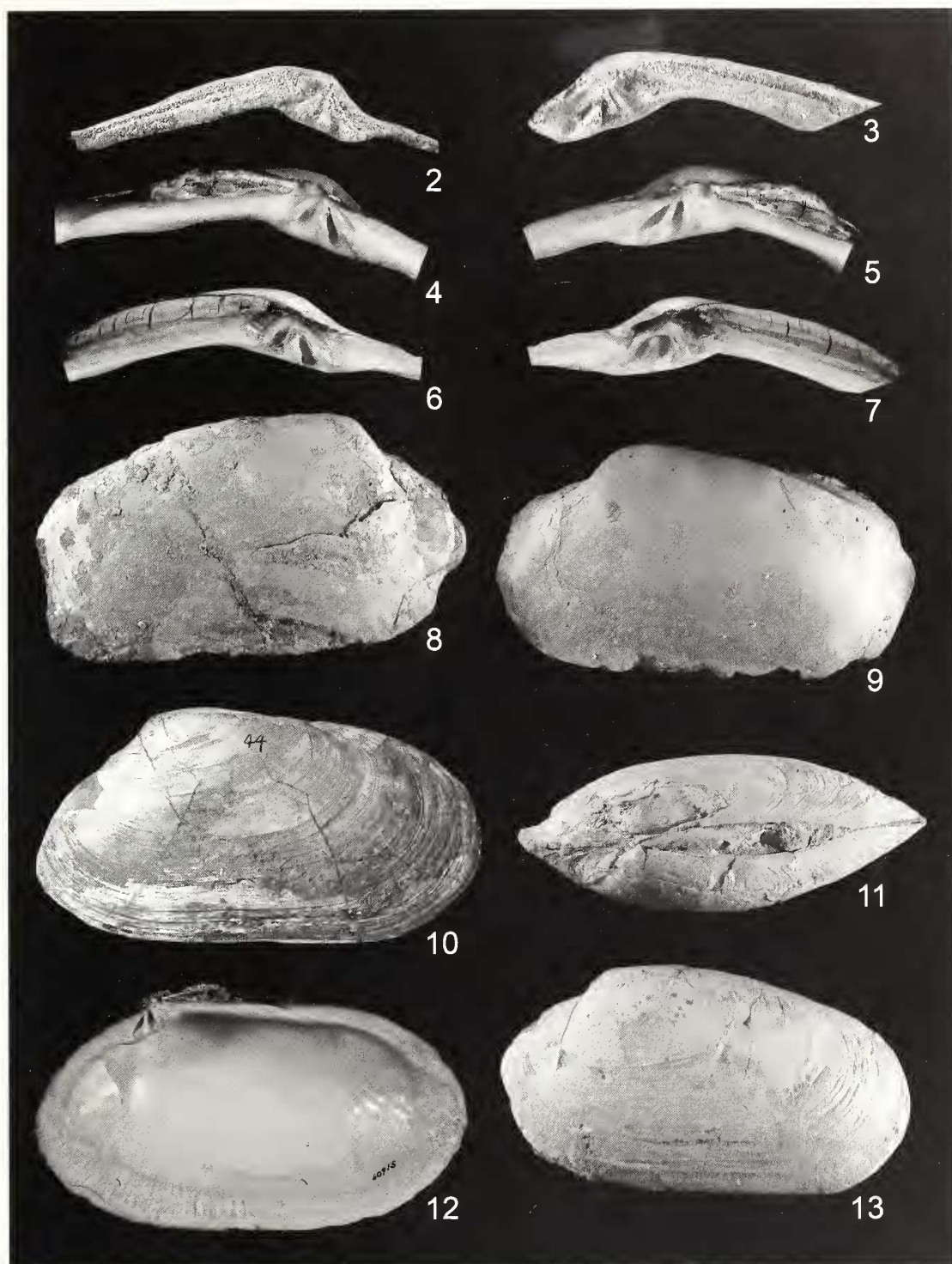
Remarks: The examined specimens were treated as *Calyptogena* cf. *nipponica* or *C.* sp. 2 by Kanno (1990, 1991, 1993). They are characterized by having an elongate ovate shell, a shallow pallial sinus, a wide subumbonal pit and a steeply sloping and bifurcated posterior cardinal tooth in the right valve. These features clearly identify these specimens as *Archivesica kawamurai* (Kuroda, 1943). Their hinge structure (Figures 2, 3) resembles that of the holotype of *Calyptogena solidissima* Okutani, Hashimoto and Fujikura, 1992, a species now considered synonym with *A. kawamurai* (Kojima et al. 2006).

As Shikama (1962) pointed out, the syntypes of *Akebiconcha kawamurai elongata* Ozaki, 1958 from the Pliocene Na-arai Formation in Chiba Prefecture are variation of this species. However, the paratype of this subspecies is from the Pliocene Ikego Formation in Kanagawa Prefecture and has a more elongate shell than the syntypes. It may belong to a new species, *Archivesica shikamai* new species, described below.

Specimens reported as *Akebiconcha nipponica* from the Pliocene Imaizumi Bed in Kanagawa Prefecture (Shikama and Masujima, 1969: pl. 7, figs. 16–19) are considered here as belonging to *Archivesica kawamurai* because the illustrated specimens are indistinguishable from *A. kawamurai* by shell form and hinge structure. Moreover, Shikama and Masujima (1969) also illustrated Recent specimens of *Archivesica kawamurai* as *Akebiconcha nipponica*. The original *Akebiconcha nipponica* was described from the upper Mioocene to lower Pliocene deposits in Niigata Prefecture (Oinomikado and Kanehara, 1938) and is discussed below.

Majima et al. (1990) illustrated *Calyptogena* sp. from the Pliocene Hijikata Formation in Shizuoka Prefecture. Judging from their illustration, shell outline and hinge structure resemble that of *A. kawamurai*.

Matsushima et al. (2003) identified two specimens from the lower Pliocene Ochiai Formation in Kanagawa Prefecture as *Calyptogena* cf. *kawamurai*. One of the specimens (their figs. 8a, b) resembles *A. kawamurai* in its outline and hinge structure, but the lack of information on its pallial sinus and the hinge structure of its right valve prevents us from



Figures 2–13. *Archivesica kawamurai* (Kuroda) (= *Calyptogena solidissima* Okutani, Hashimoto and Fujikura). 2, 3, 8. All specimens are from Loc. 1. 2. Left-valve hinge, hinge length 58.6 mm, JUE no. 15877-1. 3. Right valve hinge, hinge length 40.1 mm, JUE no. 15877-2. 8. Internal mold, view on right valve, length 106.0 mm, JUE no. 15877-3. 4, 5, 12. Holotype of *Archivesica kawamurai*, length 76.4 mm, NSMT-Mo no. 60915. 4. Left valve. 5, 12. Right valve. 6, 7. Hinge of holotype of *Calyptogena solidissima* Okutani, Hashimoto and Fujikura, length 128.5 mm, NSMT Mo-69675; 6. Left valve. 7. Right valve of which outline is shown in Figure 23. 9, 11, 13. Syntypes of *Akebiconcha kawamurai elongata* Ozaki. All specimens are from Loc. 2. 9. Internal mold, view on left valve, length 92.1 mm, NSM no. 4409. 11, 13. Specimen NSM no. 4408, seen in dorsal view and view on left valve, length 85.8 mm. 10. *Calyptogena* sp. illustrated by Majima et al. (1990, Fig. 3A). Left valve, length 63.8 mm, IGSU-M-001, Hijikata Formation.

definitely identifying it as *A. kawamurai*. The other specimen, however, (their figs. 9a, b) has many fine and regular concentric lines on its surface and a stout and posteriorly oblique middle cardinal tooth which are never seen in *A. kawamurai*.

Distribution: Pliocene: Na-arai and Kurotaki Formations in Chiba Prefecture, Ikego Formation and Imaizumi Bed in Kanagawa Prefecture, Hijikata Formation and Tamari Siltstone in Shizuoka Prefecture, Shinzato Formation in Okinawa Prefecture. Recent: Off Choshi, off Odawara, off Jogashima, Seno-Umi, Daini-Tenryu Noll, Ensei Noll, Kuroshima Noll.

Archivesica shikamai new species
(Figures 14–18, 20–22)

Akebiconcha kawamurai elongata Ozaki, 1958: pl. 6, figs. 1, 2, (non pl. 5, figs. 3, 4, pl. 6, figs. 3–5).

Calyptogena cf. *nipponica* Oinonikado and Kanehara.—Majima et al., 1990, fig. 3 Ea, Eb; Kanno, 1991: pl. 1, figs. 1a–c, pl. 2, fig. 1, (non pl. 2, figs. 2a–c, pl. 3, figs. 1–4).

Calyptogena sp. 1. Kanno, 1993: 126–132, pl. 1, figs. 1–15, pl. 2, figs. 1–12.

Diagnosis: A medium-sized *Archivesica* with elongate shell, slightly concave ventral margin, shallow pallial sinus; blunt ridge running from umbo to posterior corner; subumbonal pit wide; three radiating cardinal teeth in both valves, steeply sloping posterior tooth in right valve.

Description: Shell of medium size for genus, up to 152.4 mm long, thick-walled, elongate throughout ontogeny (height/length-ratio = 0.39–0.53), equivalve and inequilateral, weakly inflated, sculptured by growth lines only. Blunt ridge running from beak to posteroventral corner. Beak prosogyrate, situated anterior at about one-third of shell length. Anterodorsal margin broadly arched, graduating into narrowly rounded anterior margin; ventral margin slightly concave; posterodorsal margin nearly straight, gently sloping, continuing into rounded posterior margin. Escutcheon and lunule absent. Hinge plate moderately wide, with three cardinal teeth in both valves. Right valve hinge: anterior cardinal tooth (3a) thin; posterior cardinal tooth (3b) steeply oblique; central tooth (1) rather thick, vertical to hinge base; subumbonal pit wide. Left valve hinge: anterior tooth (2a) thin, oblique anteriorly, connected to stout middle tooth (2b); posterior tooth (4b) thin, oblique posteriorly; subumbonal pit wide. Nymph distinct and long, occupying two-thirds of the posterodorsal margin. Anterior adductor muscle scar subcircular; posterior one ovate; onset of pallial line near base of anterior adductor scar, obliquely crossing anteroventral shell area, pallial sinus shallow and wide; radial interior striae indistinct.

Holotype: Length 112.1 mm, height 56.1 mm, JUE no. 15878, left valve.

Paratypes: Length 106.0 mm, height 50.1 mm, JUE no. 15879-1, right valve; length 99.9 mm, height 48.3 mm,

JUE no. 15879-2, right valve; length 152.4 mm, height 68.0 mm, JUE no. 15879-3, left valve; length 76.5 mm, height 35.4 mm, JUE no. 15879-4, left valve; length 110.0 mm, height 52.1 mm, JUE no. 15879-5, left valve; all from the type locality.

Type Locality: Area currently occupied by the US Army at Ikego, Zushi City, Kanagawa Prefecture.

Material Examined: Twenty-six specimens from the type locality (Loc. 1).

Remarks: When Ozaki (1958) proposed *Akebiconcha kawamurai elongata* as a new subspecies from the Pliocene Na-arai Formation, he assigned the specimens from the Pliocene Ikego Formation (Figure 16) as a paratype of the subspecies. As noted above, the syntypes of this “subspecies” can be identified as the Recent *A. kawamurai*. The paratype of *Akebiconcha kawamurai elongata* has a more elongate shell than the syntypes of *A. kawamurai elongata* and the Recent specimens of *A. kawamurai*. Moreover, this specimen was collected from the same Ikego Formation as the present new species. Thus, the paratype can be included into the present new species.

Comparison: *Archivesica shikamai* closely resembles *A. kawamurai* in the arrangement of cardinal teeth in the right valve, but differs from it by having a more elongate shell (see Figure 24) and a wider subumbonal pit. The type material of *A. shikamai* was previously described and illustrated by Kanno (1991, 1993) as *Calyptogena* cf. *nipponica* and *Calyptogena* sp. 1. from the type locality where it co-occurs with *Archivesica kawamurai*. Such a co-occurrence of two large *Archivesica* species at a single locality resembles the co-occurrence of *A. soyoe* (Okutani) and *A. okutanii* (Kojima and Ohta) in Sagami Bay today.

Distribution: Pliocene Ikego Formation in Kanagawa Prefecture.

Etymology: Named after the late Emeritus Prof. Tokio Shikama (Yokohama National University), a molluscan paleontologist, who also studied the molluscan fauna from the Ikego Formation.

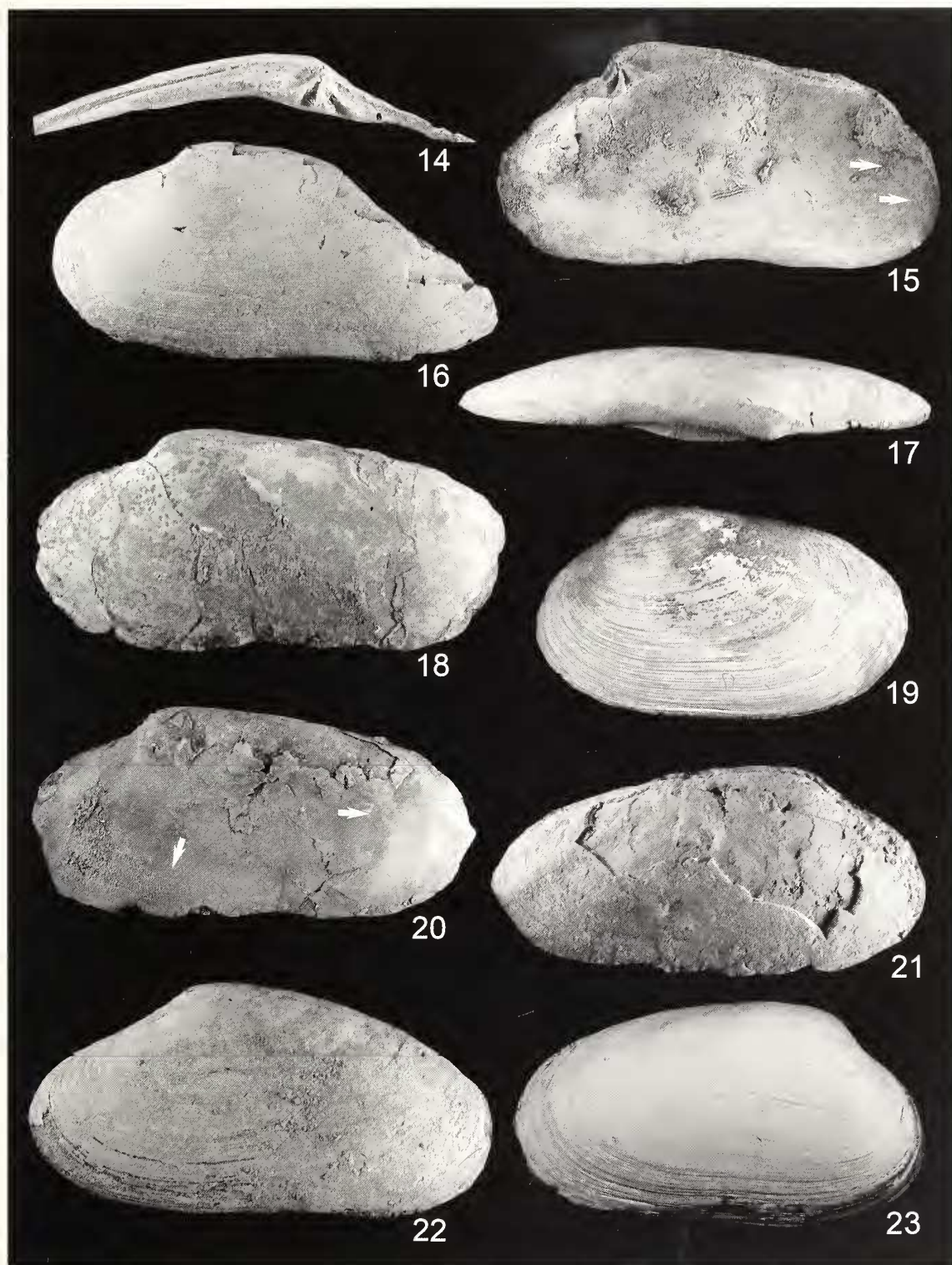
Archivesica kannoi new species
(Figures 25–31)

Calyptogena nipponica Oinonikado and Kanehara.—Kanno, 1993: pl. 7, figs. 4–9; Amano, 1994, pl. 2, figs. 1, 3, 8, 11.

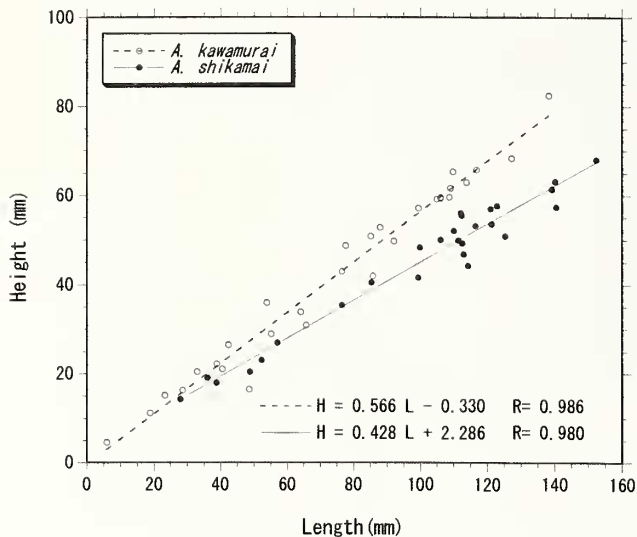
Calyptogena cf. *nipponica* Oinonikado and Kanehara.—Amano and Kanno, 2005: 207–208, figs. 4, 5, 11–13.

Diagnosis: A medium-sized *Archivesica* with elongate quadrate shell, very shallow pallial sinus; subumbonal pit small but deep; three radiating cardinal teeth in both valves.

Description: Shell of moderate size for genus, up to 124.6 mm long, thin-walled, elongate quadrate in adults (height/length-ratio = 0.48–0.57; length > 40 mm; Figure 32), elongate ovate in juvenile (height/length-ratio = 0.49–0.76; length < 40 mm), equivalve and inequilateral, moderately inflated, sculptured only by fine growth lines.



Figures 14–23. *Archivesica shikamai* new species. All specimens are from Loc. 1. **14, 17, 22.** Holotype, length 112.1 mm, JUE no. 15857. **14.** Right-valve hinge, hinge length 59.4 mm. **17.** Dorsal view. **22.** Left valve. **15.** Paratype, length 106.0 mm, JUE no. 15879-1, inner part of left valve, white arrows indicating the pallial sinus. **18.** Paratype, internal mold, length 76.5 mm, JUE no. 15879-4, left valve. **20.** Paratype, internal mold, length 110.0 mm, JUE no. 15879-5, left valve, white arrows indicating pallial line and sinus. **21.** Paratype, length 99.9, JUE no. 15879-2, right valve. **16.** Paratype of *Akebiconcha kawamurai elongata*, length 112.3 mm, NSH 4441. **19, 23.** *Archivesica kawamurai* (Kuroda). **19.** Holotype of *Archivesica kawamurai*, length 76.4 mm, NSMT-Mo no. 60915, left valve. **23.** Holotype of *Calyptogenia solidissima* Okutani, Hashimoto and Fujikura, length 128.5 mm, NSMT Mo-69675, right valve.



Figures 24. Diagram showing height/length-ratios of *Archivesica kawamurai* and *A. shikamai* new species

Beak prosogyrate, situated anteriorly at about one-fourth of shell length. Antero-dorsal margin broadly arcuated, graduating into narrowly rounded anterior margin; ventral margin broadly arcuated; posterodorsal margin straight, gently sloping, graduating into rounded posterior margin. Escutcheon and lunule absent. Hinge plate with three cardinal teeth in both valves. Right valve hinge: anterior cardinal tooth (3a) very thin along dorsal margin; posterior cardinal tooth (3b) oblique; central tooth (1) rather thick, vertical to hinge base; subumbonal pit narrow. Left valve hinge: anterior tooth (2a) thin, oblique anteriorly, connected to stout middle tooth (2b); posterior tooth (4b) thin, oblique posteriorly; subumbonal pit narrow and shallow behind posterior tooth. Nymph distinct, occupying two-thirds of the posterodorsal margin. Anterior adductor muscle scar pear-shaped; posterior one ovate; deep groove observed just behind anterior adductor scar and just before posterior scar. Pallial line starts near posteroventral corner of anterior adductor scar, running mostly parallel to ventral shell margin, pallial sinus varying from very shallow to shallow. Inner shell surface finely and weakly crenulated.

Holotype: Length 124.6 mm, height 66.3 mm, JUE no. 15880, left valve.

Paratype: Length 62.6 mm+, height 37.9 mm, JUE no. 15881-1, right valve; length 48.7 mm, height 28.1 mm, JUE no. 15881-2, right valve; length 79.1 mm+, height 45.9 mm, JUE no. 15881-3, left valve; length 38.4 mm, height 18.9 mm, JUE no. 15881-4, right valve; length 37.4 mm, height 20.9 mm, JUE no. 15881-5, right valve.

Type Locality: 1 km west to Matsudai, Tokamachi City, Niigata Prefecture (Loc. E2 by Amano and Kanno, 2005).

Material Examined: Thirty-eight specimens from the type locality (Loc. 3).

Remarks: *Archivesica kannoi* new species was described or illustrated as *Calypptogena nipponica* or *C. cf. nipponica* by Kanno (1993), Amano (1994) and Amano and Kanno (2004). However, the hinge of the type *C. nipponica* can partly be observed and the condition of pallial line is unknown. Moreover, the type material of *Calypptogena nipponica* was probably destroyed during World War II. Thus, it is difficult to compare this new species to *C. nipponica*.

Comparisons: *Archivesica kannoi* new species is most similar to *A. shiretokensis* (Uozumi, 1967) from the upper Miocene Rurua Formation in Hokkaido regarding size and hinge structure. *Archivesica kannoi* differs from *A. shiretokensis* by having a less concave ventral margin, a vertical middle tooth in the right valve and a very shallow pallial sinus. The Recent species, *A. soyogae* (Okutani, 1957) can be distinguished from *A. kannoi* by its slightly concave ventral margin, its slightly bifid posterior tooth in the right valve, and its deeper pallial sinus. Some specimens have a "broad" or secondary pallial line running closer to the shell margin and roughly parallel to the real pallial line except for the posterior area where it does not form a pallial sinus but ends at the posterior side of the posterior adductor scar (see Figure 31). This "broad" or secondary pallial line can also be seen in other large *Archivesica* species such as *A. kawamurai* (see Figure 12 of the holotype of the latter species).

Distribution: Lower Pliocene part of the Kurokura Formation in Niigata Prefecture.

Etymology: Named after the late Emeritus Prof. Saburo Kanno (University of Tsukuba and Joetsu University of Education), a molluscan paleontologist, who studied the vesicomyids from the Kurokura Formation.

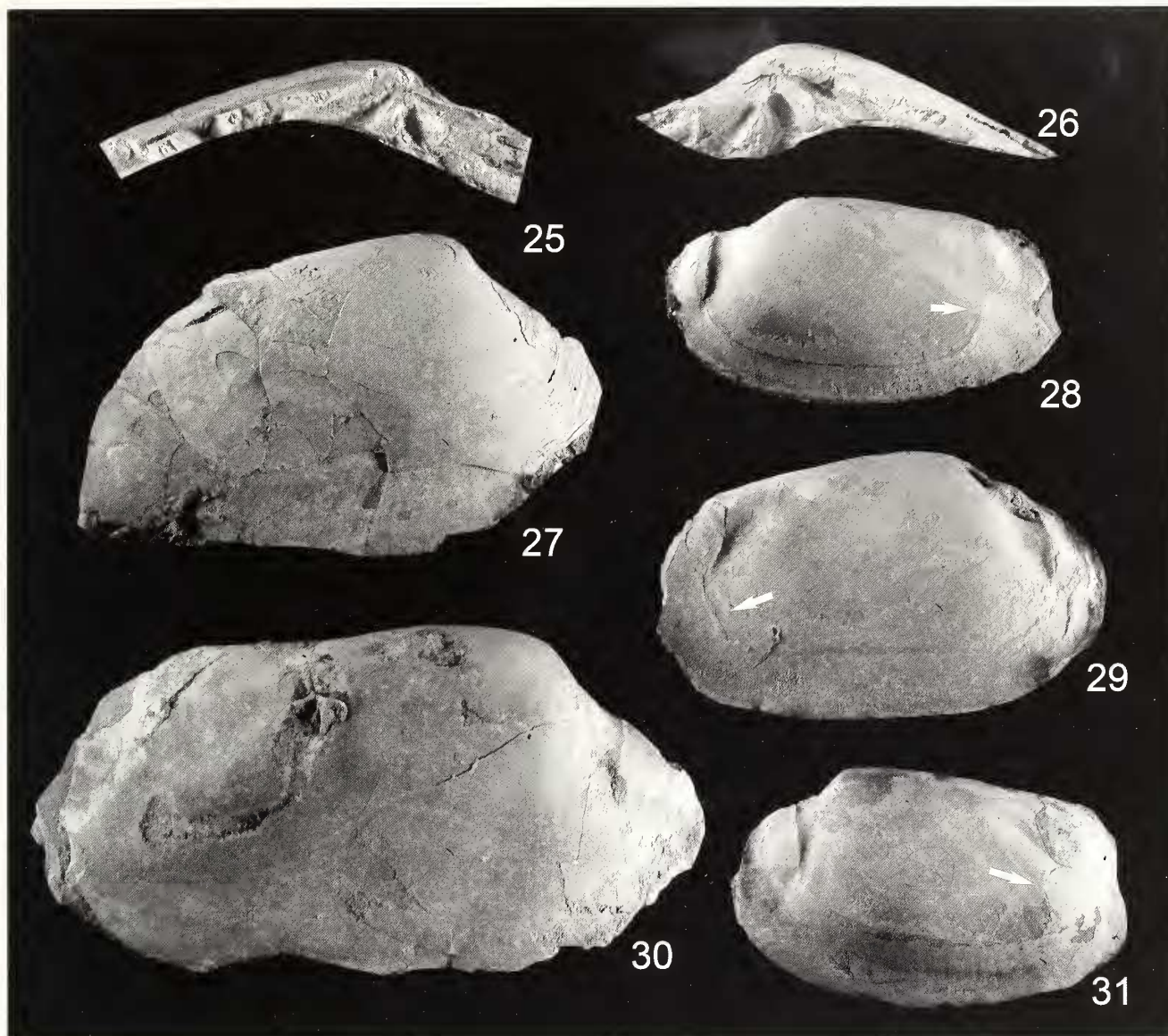
Archivesica nipponica (Oinomikado and Kanehara, 1938)

Calypptogena nipponica Oinomikado and Kanehara, 1938: p. 677–678, pl. 21, figs. 1–5.

non *Akebiconcha nipponica* (Oinomikado and Kanehara; Shikama and Masujima, 1969: pl. 7, figs. 16–19.

Type Material: The type material was deposited in the Imperial Geological Survey of Japan, and was destroyed according to Hatai and Nisiyama (1952).

Remarks: Oinomikado and Kanehara (1938) described *Calypptogena nipponica* from the lower Pliocene "Ushigakubi bed" [= upper part of Araya Formation; Kobayashi et al., 1991] and from the cuttings of a well dug into the upper Miocene? "Kubiki Series". Regarding its size (holotype length 115.4 mm), outline, the three strong, radiating cardinal teeth, and the narrow and shallow subumbonal pit in the right valve, this species is similar to *Archivesica soyogae* and presumably belongs to the genus *Archivesica*. The posterior cardinal tooth of the right valve of *Archivesica nipponica* does not bend towards the anterior, which precludes its placement within *Calypptogena*. However, most inner features



Figures 25–31. *Archivesica kannoi* new species. All specimens are from Loc. 3. **25.** Paratype, hinge length of left valve 33.8 mm, JUE no. 15881-3. **26, 27.** Paratype, JUE no. 15881-1. **26.** Right valve hinge, hinge length 24.0 mm. **27.** Right valve, length 62.6 mm+. **28.** Paratype, internal mold, length 38.4 mm, JUE no. 15881-4, left valve, white arrow indicating the very shallow pallial sinus. **29.** Paratype, internal mold, length 48.7 mm, JUE no. 15881-2, right valve, white arrow indicating the very shallow pallial sinus. **30.** Holotype, internal mold, length 124.6 mm, JUE no. 15880, right valve. **31.** Paratype, internal mold, length 37.4 mm, JUE no. 15881-5, left valve, white arrow indicating the shallow pallial sinus.

except for the ill-preserved right valve hinge are unknown. The type locality has been visited twice by the senior author but new material of *Archivesica nipponica* was not found. Thus its characters and relationships to other vesicomyids remain unclear.

Distribution: Upper Miocene? “Kubiki Series” in Niigata Prefecture; Lower Pliocene part of the Araya Formation in Niigata Prefecture.

Archivesica shiretokensis (Uozumi, 1967)

“*Calyptogena*” *shiretokensis* Uozumi in Uozumi and Ishikawa, 1967: p. 44, fig. 3

Archivesica shiretokensis (Uozumi).—Amano and Suzuki, 2010: 165–171, fig. 2 A–J.

Holotype: Type specimens were assigned and illustrated by Uozumi (1967) but their repository is unknown.

Remarks: Recently Amano and Suzuki (2010) collected topotype specimens and redescribed *Archivesica nipponica* in detail.

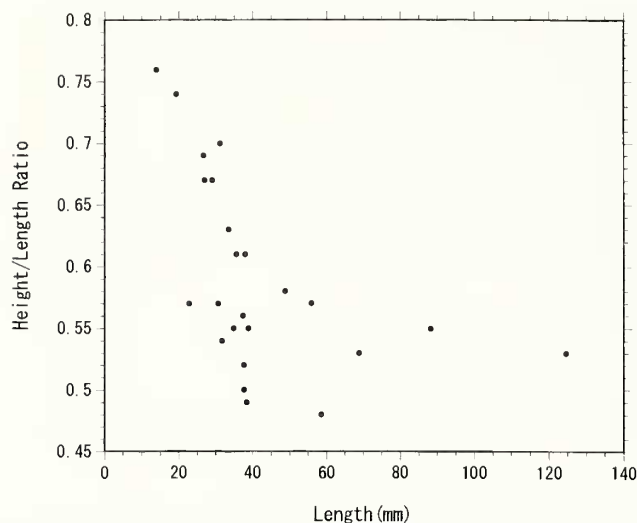


Figure 32. Relationship between shell length and the height/length ratio of *Archivesica kannoi* new species.

Distribution: Upper Miocene Rusha Formation in Hokkaido.

Archivesica sp.

Calyptogena sp. Nobuhara and Takatori, 1999: 145, Pl. 1, figs. 5–10.

Specimens: ESN nos. 2695–2700.

Remarks: This species has a large shell exceeding 130 mm in length, a posteriorly oblique posterior tooth (3b) in the right valve on which a distinct groove can be recognized, and a deep subumbonal pit. As Nobuhara and Takatori (1999) pointed out, these features are recognized in *A. soyoae* and *A. okutanii* (Kojima and Ohta, 1997). However, due to the poor preservation of the sixteen specimens collected and illustrated by Nobuhara and Takatori (1999), a species-level identification is currently not possible.

Distribution: Pliocene Horinouchi Formation in Shizuoka Prefecture.

?*Archivesica bosoensis* (Kanie and Kuramochi, 2001)

Calyptogena sp. Majima et al., 1992: p. 373–376, figs. 3.1–3.3.
Calyptogena (Ectenagena) sp. Kanie et al., 1997: p. 794–795, figs. 2.1a–c.

Calyptogena bosoensis Kanie and Kuramochi, 2001: p. 6–8, figs. 3.1–3.2, 4Cb.

Holotype: YCM-GP no. 1143.

Paratype: YCM-GP no. 1144.

Remarks: ?*Archivesica bosoensis* reaches 235 mm in length, which is close to the maximum size of *Archivesica*. Kanie and Kuramochi (2001) pointed out that ?*A. bosoensis* is very similar in shape to the Recent *A. similis* Okutani, Kojima, and Ashi, 1997, except for its much larger size. Another species that is similar in shape and size is the Recent “*Calyptogena*” *garuda* from 2064 to 2137 m depth off Java, Indonesia (Okutani and Soh, 2005). Judging from its size and outline, ?*Archivesica bosoensis* probably belongs to the genus *Archivesica*, but this assessment has to remain tentative until better preserved material becomes available.

Distribution: Pliocene Shiramazu Formation in Chiba Prefecture.

DISCUSSION

The genus *Archivesica* first appeared in Japan in the late Miocene with two species; an additional four species appear in the Pliocene (Table 1, Figure 33). Today, eight species and one subspecies of *Archivesica* are living around the Japanese Islands (Sasaki et al., 2005; Okutani et al., 2009). On the northern and eastern side of the Pacific *Archivesica* has a much longer fossil record, ranging back to the middle Eocene of Washington State and the Oligocene of Alaska (Amano and Kiel, 2007; Kiel and Amano, 2010). But these Pliocene species are much smaller (max. 48 mm) than those reported here from the Japanese Neogene (112 to 235 mm) and most have a lumular incision, a feature not seen in the large Neogene species of *Archivesica*. The large vesicomyids known

Table 1. Age and characteristics of fossil *Archivesica* species in Japan. Position of umbo is expressed as percentage along shell length from anterior end.

Species	Age	Maximum length (mm)	Shell shape	H/L	Position of umbo (%)	Steeply oblique 3b tooth	Bifid 3b tooth	Subumbonal pit	Pallial sinus	
<i>A. shiretokensis</i>	Late Miocene	152.6	elongate-elliptical	0.44–0.48	16–22	–	+	(weak)	narrow, shallow	shallow
<i>A. nipponica</i>	Late Miocene–Early Pliocene	115.4	elongate-elliptical	0.40	25–33	–	–		narrow, shallow	?
<i>A. kannoi</i> n. sp.	Early Pliocene	124.6	elongate-quadrate	0.48–0.76	17–33	–	–		narrow, shallow	very shallow
<i>A. shikamai</i> n. sp.	Pliocene	152.4	very elongate-elliptical	0.39–0.53	27–40	+	–		wide	shallow
<i>A. kawamurai</i>	Pliocene–Recent	138.9	elongate-elliptical	0.54–0.62	26–36	+	+		wide	shallow
<i>A.</i> sp.	Pliocene	>130.0	whole outline unknown	?	?	–	+		narrow, deep	?
<i>A.?</i> <i>bosoensis</i>	Pliocene	235.0	very elongate-elliptical	0.35–0.38	23–26	?	?		?	?

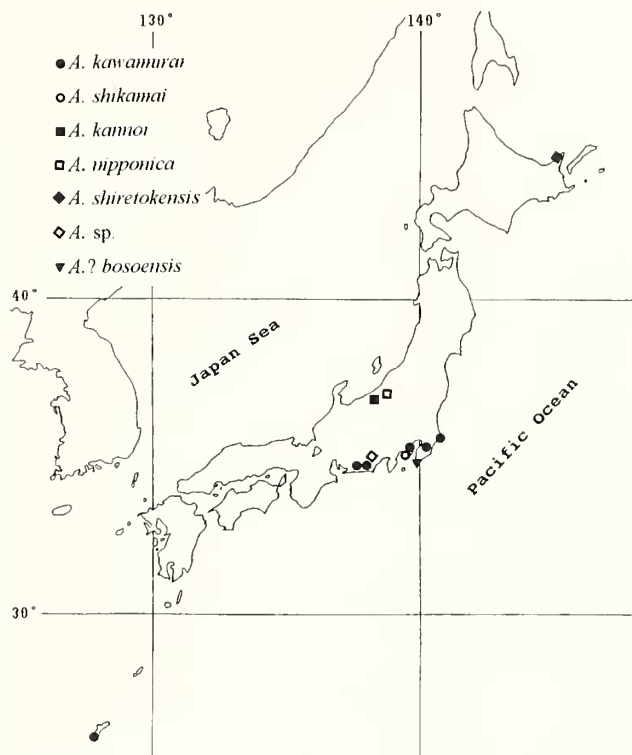


Figure 33. Distribution of fossil *Archivesica* in Japan. *A. shiretokensis*: late Miocene; *A. nipponica*: late Miocene to early Pliocene; *A. kanno*: early Pliocene; *A. shikamai*: Pliocene; *A. sp.*: Pliocene; *?A. bosoensis*: Pliocene; *A. kawamurai*: Pliocene to Recent.

from Cenozoic seep deposits in the Caribbean region (Gill et al., 2005; Kiel, 2007; Kiel and Peckmann, 2007) are of the elongate type around the genus *Adulomya*. The earliest record of a “large *Archivesica*” from the American Pacific coast is *A. gibbera* from the early Pliocene of California (Crickmay, 1929; Squires, 1991). This pattern of occurrence suggests that the “large *Archivesica*” originated in the western Pacific sometime during the middle/late Miocene and subsequently spread eastward to North America. However, because no vesicomyids have been reported so far from the late Miocene of western North America, this scenario remains tentative. Interesting in the context of the dispersal history of the “large *Archivesica*” in the Pacific are the “large vesicomyids” recently reported from lower Pliocene cold seep deposits in the eastern central Philippines (Majima et al. 2007), because of the similarities between the Pliocene Japanese *?Archivesica bosoensis* and the modern Indonesian *A. garuda*.

The diversification history of the Neogene “large *Archivesica*” in Japan is in an interesting contrast to the evolutionary history of the large, elongate vesicomyid genus *Adulomya*. *Adulomya* first appeared in Japan in the early Miocene, it was present with five species during the early and middle Miocene, and experienced a steep decline in diversity through the late Miocene and Pliocene (Amano and Kiel, in press). This decline in diversity

might relate to the rise of the “large *Archivesica*” from the late Miocene onward. Different again is the history of *Calypptogena* in Japan, which first appeared with one species in the late Miocene (Kanno et al., 1989) and maintained a low diversity until today (Sasaki et al., 2005; Okutani et al., 2009).

Both fossil and Recent records of *Archivesica kawamurai* are confined to the accretionary prism on the Pacific side of southwestern Honshu, an area with many cold-seep sites (Fujioka and Taira, 1989; Kojima, 2002), indicating that *A. kawamurai* has not changed its area of distribution since the Pliocene. Such distribution pattern might relate to stable environmental conditions in this area: the basic tectonic framework of Japan has not changed from the late Miocene to the Recent (e.g. Iijima and Tada, 1990) probably resulting in constant methane seepage along the accretionary prism off southwestern Honshu.

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LITERATURE CITED

- Amano, K. 1994. Pliocene molluscan fauna and its environment in Matsunoyama-machi, Niigata Prefecture. *Journal of Geography* 103: 653–673. [in Japanese with English abstract]
- Amano, K. 2003. Predatory gastropod drill holes in Upper Miocene cold seep bivalves, Hokkaido, Japan. *The Veliger* 46: 90–96.
- Amano, K. and S. Kanno. 2005. *Calypptogena* (Bivalvia: Vesicomyidae) from Neogene strata in the Joetsu District, Niigata Prefecture, central Japan. *The Veliger* 47: 202–212.
- Amano, K. and S. Kiel. 2007. Fossil vesicomyid bivalves from the North Pacific region. *The Veliger* 49: 270–293.
- Amano, K. and S. Kiel. in press. Fossil *Adulomya* (Vesicomyidae, Bivalvia) from Japan. *The Veliger* 51.
- Amano, K. and A. Suzuki. 2010. Redescription of “*Calypptogena*” *shiretokensis* Uozumi (Bivalvia: Vesicomyidae) from the Miocene Rusa Formation on the Shiretoko Peninsula, eastern Hokkaido, Japan. *Venus* 68: 165–171.
- Crickmay, C.H. 1929. On a new pelecypod *Calypptogena gibbera*. *The Canadian Field-Naturalist* 43: 93.
- Dall, W.H. 1891. Scientific results of explorations by the U.S. Fish Commission Steamer Albatross. XX. On some new or interesting West American shells obtained from dredgings of the U.S. fish commission steamer Albatross in 1885. *Proceedings of the U.S. National Museum* 14: 174–191.

- Dall, W.H. 1896. Diagnoses of new species of mollusks from the west coast of America. *Proceedings of the U.S. National Museum of Natural History* 18: 7–20.
- Dall, W.H. 1908. Reports on the dredging operations off the west coast of Central America ... The Mollusca and Brachiopoda. *Bulletin of the Museum of Comparative Zoology at Harvard University* 43: 205–487.
- Dall, W.H. and C.T. Simpson. 1901. The Mollusca of Porto Rico. *Bulletin of the United States, Fish and Fisheries Commission* 20: 351–524.
- Fujioka, K. and A. Taira. 1989. Tectono-sedimentary settings of seep biological communities. A synthesis from the Japanese subduction zone. In: Taira, A. and F. Masuda (eds.). *Sedimentary facies in the active plate margin*. Terrapub, Tokyo, 577–602.
- Gill, F.L., I.C. Harding, C.T.S. Little, and J.A. Todd. 2005. Palaeogene and Neogene cold seep communities in Barbados, Trinidad and Venezuela: An overview. *Palaeogeography, Palaeoclimatology, Palaeoecology* 227: 191–209.
- Habe, T. 1951. *Genera of Japanese Shells*, no. 2. Kairui Bunken Kanko Kai, Kyoto: 97–186. [in Japanese]
- Habe, T. 1961. Colored Illustration of the Shells of Japan (II). Hoikusha, Osaka, xii+183 pp. [in Japanese]
- Habe, T. 1977. *Systematics of Mollusca in Japan. Bivalvia and Scaphopoda*. Zukan-no-Hokuryukan, Tokyo, 372 pp. [in Japanese]
- Hachiya, H. 1904. Geology of the Iwaki Volcano. Report of the Imperial Earthquake Investigation Committee 48: 1–51. [in Japanese]
- Hatai, K. and S. Nisiyama. 1952. Check list of Japanese Tertiary marine Mollusca. *Science Report of the Tohoku University, Special Volume* 3: 1–464.
- Horikoshi, M. 1989. Deep-sea giant white clams, *Calyptogena* s.l., found in the hot-vent and cold-seep sites. *Venus, Supplement* 1: 59–74. [in Japanese with English abstract]
- Iijima, A. and Tada, R., 1990: Evolution of Tertiary sedimentary basins of Japan in reference to opening of the Japan Sea. *Journal of the Faculty of Science, the University of Tokyo, Section 2* 22: 121–171.
- Kanie, Y., and T. Kuramochi. 2001. Two new species of the Vesicomidae (Bivalvia: Mollusca) from the Pliocene Shiramazu Formation of the Chikura Group in the Boso Peninsula, Japan. *Science Reports of the Yokosuka City Museum* 48: 1–9. [in English with Japanese abstract]
- Kanie, Y., M. Hattori, T. Kuramochi, H. Okada, T. Ohba, and C. Honma. 1997. Two vesicomid Bivalvia from the Shiramazu Formation of the Chikura group in the southernmost part of the Boso Peninsula. *Journal of the Geological Society of Japan* 103: 794–797. [in Japanese]
- Kanno, S. 1990. On the fossil “*Calyptogena*” from the Ikego area loaned to US Army. In: Taira, A. (ed.). Report of the fossil “*Calyptogena*”. Yokohama Defense Facilities Administration Bureau, Yokohama: 91–106. [in Japanese, title translated]
- Kanno, S. 1991. On the fossil “*Calyptogena*” from the vicinity of Zushi City. In: Horikoshi, M. (ed.). Report of the fossil “*Calyptogena*” in Ikego, Zushi City. Education Board of Zushi City: 60–69. [in Japanese, title translated]
- Kanno, S. 1993. On the fossils of “*Calyptogena*” from Ikego (2nd Report). In: Hasegawa, Y. (ed.). Last report of the fossil “*Calyptogena*” from Ikego. Yokohama Defense Facilities Administration Bureau, Yokohama: 123–162. [in Japanese, title translated]
- Kanno, S., K. Amano, and H. Ban. 1989. *Calyptogena* (*Calyptogena*) *pacifica* Dall (Bivalvia) from the Neogene system in the Joetsu district, Niigata prefecture. *Transactions and Proceedings of the Palaeontological Society of Japan, New Series* 153: 25–35.
- Keen, M. 1969. Family Vesicomidae. In: C. Moore (ed.) *Treatise on Invertebrate Paleontology, Part N*, vol. 2 (of 3). University of Kansas and Geological Society of America, Lawrence: N663–664.
- Kiel, S. 2007. Status of the enigmatic fossil vesicomid bivalve *Pleurophopsis*. *Acta Palaeontologica Polonica* 52: 639–642.
- Kiel, S. and K. Amano. 2010. Oligocene and Miocene vesicomid bivalves from the Katalla district in southern Alaska, USA. *The Veliger* 51: 76–84.
- Kiel, S. and J. Peckmann 2007. Chemosymbiotic bivalves and stable carbon isotopes indicate hydrocarbon seepage at four unusual Cenozoic fossil localities. *Lethaia* 40: 345–357.
- Kobayashi, I., M. Tateishi, T. Yoshioka, and M. Shimazu. 1991. *Geology of the Nagaoka District*. Geological Survey of Japan, Tsukuba, 132 pp. [in Japanese with English abstract]
- Kojima, S. 2002. Deep-sea chemoautosynthesis-based communities in the Northwestern Pacific. *Journal of Oceanography* 58: 343–363.
- Kojima, S. and Ohta, S. 1997. *Calyptogena okutanii* n. sp., a sibling species of *Calyptogena soyoeae* Okutani, 1957 (Bivalvia: Vesicomidae). *Venus* 56: 189–195.
- Kojima, S., E. Tsuchida, H. Numanami, K. Fujikura and T. Okutani 2006. Synonymy of *Calyptogena solidissima* with *Calyptogena kawamurai* (Bivalvia: Vesicomidae) and its population structure revealed by mitochondria DNA sequences. *Zoological Science* 23: 835–842.
- Kuroda, T. 1931. Fossil Mollusca. In: Homma, F. (ed.) *Geology of the central part of Shinano, part 4*. Kokin Shoin, Tokyo, 90 pp. [in Japanese]
- Kuroda, T. 1943. *Akebiconcha*, a new pelecypod genus. *Venus* 13: 14–18. [in Japanese with English description]
- Majima, R., S. Imai, R. Uchimura, S. Kida, and M. Hayakawa. 1990. Finding of *Calyptogena* sp. (Bivalvia) from the Late Pliocene Hijikata Formation, Kakegawa City, Shizuoka Prefecture, central Japan. *Journal of the Geological Society of Japan* 96: 553–556. [in Japanese]
- Majima, R., T. Kase, S. Kawagata, Y.M. Aguilar, K. Hagino and M. Maeda. 2007. Fossil cold-seep assemblages from Leyte Island, Philippines. *Journal of Geography* 116: 643–652. [in Japanese with English abstract]
- Majima, R., T. Nobuhara, and T. Kitazaki. 2005. Review of fossil chemosynthetic assemblages in Japan. *Palaeogeography, Palaeoclimatology, Palaeoecology* 227: 86–123.
- Majima, R., S. Tanase, R. Uchimura, and T. Honme. 1992. Finding of *Calyptogena* sp. (Bivalvia) from the Neogene of the southern end of the Boso Peninsula, central Japan. *Journal of the Geological Society of Japan* 98: 373–376. [in Japanese with English abstract]
- Matsushima, Y., K. Taguchi, and K. Chinzei. 2003. Molluscan fossils from the Ochiai Formation, the Tanzawa Mountains, central Japan. *Bulletin of the Kanagawa Prefecture Museum, Natural Science* 32: 27–68. [in Japanese with English abstract]
- Nobuhara, T. 2003. Cold see carbonate mounds with *Vesicomya* (*Calyptogena*) *kawamurai* (Bivalvia: Vesicomidae) in slope-mud facies of the Pliocene forearc basin of Sagara-Kakegawa area, central Japan. *Paleontological Research* 7: 313–328.

- Nobuhara, T. and R. Takatori. 1999. Occurrence of *Calypptogena* sp. (Bivalvia: Vesicomyidae) from the Pliocene Horinouchi Formation, Shizuoka Prefecture, central Japan. *Journal of the Geological Society of Japan* 105: 140–150. [in Japanese with English abstract]
- Nobuhara, T. and Tanaka, 1993. Paleoeecology of *Akebiconcha kavanurai* (Bivalvia: Vesicomyidae) from the Pliocene Tamari Silt Formation in the Kakegawa area, central Japan. *Palaeogeography, Palaeoclimatology, Palaeoecology* 102: 27–40.
- Noda, H. 1980. Molluscan fossils from the Ryukyu Islands, southwestern Japan: Part 1. Gastropoda and Pelecyopoda from the Shinzato Formation in southeastern part of Okinawa-jima. *Science Report of the Institute of Geoscience, University of Tsukuba, Section B*. 1: 1–95.
- Nomura, S. 1935. Mioene Mollusca from the Nishi-Tsugaru District, Aomori-Ken, Northeast Honshu, Japan. *Saito Ho-on Kai Museum, Research Bulletin* 6: 19–74.
- Oinomikado, T. and K. Kanehara. 1938. A new species of *Calypptogena* from the Higashiyama Oil Field, Niigata-Ken, Japan. *Journal of the Geological Society of Japan* 45: 677–678.
- Okutani, T. 1966. Identify of *Calypptogena* and *Akebiconcha* (Bivalvia, Cyprinidae). *Venus* 24: 297–303. [in Japanese with English summary]
- Okutani, T. 2000. Vesicomyidae. In: Okutani, T. (ed.) *Marine molluscs in Japan*. Tokai University Press, Tokyo: 996–999. [in Japanese and English]
- Okutani, T., J. Hashimoto, and K. Fujikura. 1992. A new species of vesicomyid bivalve associated with hydrothermal vents near Amami-Oshima Island, Japan. *Venus* 51: 225–233.
- Okutani, T., T. Koshi-ishi, T. Sato, T. Imai, and C. Kato. 2009. Vesicomyid fauna in the Chishima (Kurile) Trench: Occurrences of a new taxon and *Calypptogena extenta*. *Venus* 68: 15–25.
- Okutani, T. and W. Soh. 2005. *Calypptogena (Archivesica) garuda*, a magnificent new species of vesicomyid bivalve from the Java Trench, Indonesia. *Venus* 64: 23–29.
- Olsson, A.A. 1931. Contributions to the Tertiary paleontology of northern Peru. Part 4. The Peruvian Oligocene. *Bulletins of American Paleontology* 17: 97–264.
- Ozaki, H. 1958. Stratigraphical and paleontological studies on the Neogene and Pleistocene formations of the Tyosi district. *Bulletin of the National Science Museum, New Series* 4: 1–182.
- Sasaki, T., T. Okutani, and K. Fujikura. 2005. Molluscs from hydrothermal vents and cold seeps in Japan: A review of taxa recorded in twenty recent years (1984–2004). *Venus* 64: 87–133.
- Shikama, T. 1962. On some noteworthy shells from off Choshi, Chiba Prefecture. *Science Reports of the Yokohama National University* 8: 29–56.
- Shikama, T. and A. Masujima. 1969. Quantitative studies of the molluscan assemblages in the Ikego-Nojima formations. *Science Reports of the Yokohama National University* 15: 61–94.
- Squires, R.L. 1991. New morphologic and stratigraphic information on *Calypptogena (Calypptogena) gibbera* Crickmay, 1929, (Bivalvia: Vesicomyidae), from the Pliocene and Pleistocene of southern California. *The Veliger* 34: 73–77.
- Takeda, H. 1953. The Poronai Formation (Oligocene Tertiary) of Hokkaido and South Sakhalin and its fossil fauna. *Studies on Coal Geology, the Hokkaido Association of Coal Mining Technologists* 3: 1–103.
- Tsuehida, E. 1986. *Akebiconcha kavanurai* collected from Off Kii Channel. *Chiribotan* 17: 29–31. [in Japanese]
- Uozumi, S. and Ishikawa, T. 1967. Fossils from Shiretoko Peninsula. In: Education Board of Hokkaido (ed.) *Cultural properties in Hokkaido* 9, Shiretoko Peninsula. pp. 43–44, Education Board of Hokkaido, Sapporo. [in Japanese, title translated]